

## PATENT ABSTRACTS OF JAPAN

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(22)Date of filing : 31.01.1992 (72)Inventor : MATSUBARA TATSUO

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### (54) MANUFACTURE OF POLYOLEFIN FOAM

#### (57)Abstract:

**PURPOSE:** To provide a process by which to manufacture efficiently an end foam with a bubble diameter which is not too small nor too large at an expansion ratio of 10 or higher.

**CONSTITUTION:** The subject manufacture is intended for an end foam formed 10 times as large using a blend of polyolefin, a cross-linking agent and a foaming agent. The blend is fully poured in a primary molding die, and this is heated under a pressurized state at 50kg/cm<sup>2</sup> or higher. Consequently, the die is placed under a decompressed state to allow the primary inflation of the blend after decomposition of the cross-linking agent and the foaming agent. Thus the primary foam obtained has a volume inflation rate equivalent to 1/7 or lower of the total inflation rate of the end foam, and the primary expansion ratio of 10 or lower. Next, the primary foam is heated at normal pressure in the secondary molding die, and is secondarily inflated at a volume inflation rate of minimum 7 times and maximum 10 times as much as the primary foam to obtain the end foam (the average bubble diameter is 250 to 450μm) of polyolefin.

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**CLAIMS**

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**[Claim(s)]**

[Claim 1] In the approach of manufacturing the last foam made foaming to 10 or more times using the admixture which consists of polyolefine, a cross linking agent, and a foaming agent It is filled up with the above-mentioned admixture in primary metal mold, and is this primary metal mold 50 kg/cm<sup>2</sup> By heating in the state of the above application of pressure Some of above-mentioned cross linking agents and above-mentioned foaming agents are made to disassemble, it decompresses after that, and it is made to expand primarily and the primary foam in which it is 1/7 or less, and primary expansion ratio has a less than 10-time coefficient of cubical expansion is manufactured to the total dilatation of the last foam in a coefficient of cubical expansion. Subsequently The manufacture approach of the polyolefine foam characterized by putting in this primary foam in secondary metal mold, heating by ordinary pressure, being 7 or more times, and expanding the 2nd order with a less than 10-time coefficient of cubical expansion to this primary foam, and manufacturing the above-mentioned last foam.

[Claim 2] The diameter of average air bubbles of the above-mentioned last foam is the manufacture approach of the polyolefine foam according to claim 1 which is 250-450 micrometers.

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**DETAILED DESCRIPTION**

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**[Detailed Description of the Invention]****[0001]**

**[Industrial Application]** This invention relates to the approach the diameter of air bubbles manufactures efficiently the polyolefine foam made to foam to about 250–450 micrometers and 10 or more times which was greatly [ comparatively ] rich in compressive stress, if it says in more detail about the manufacture approach of polyolefine foam.

**[0002]**

**[Description of the Prior Art]** As the manufacture approach of the block foam of polyolefine How (one-step foaming is called hereafter.) to expand the consistency of at once a request of this admixture by filling up metal mold with the admixture of polyolefin resin, a cross linking agent, and a foaming agent, disassembling the cross linking agent and a foaming agent thoroughly in the state of application of pressure and heating generally, and decompressing after that And the method of filling up primary metal mold, heating admixture under application of pressure, expanding it primarily as indicated by JP,52-8348,B, JP,2-42649,B, etc., heating the foam by ordinary pressure after that, expanding the 2nd order, and obtaining the foam of a desired consistency (two-step foaming is called hereafter.) It is known.

**[0003]**

**[Problem(s) to be Solved by the Invention]** However, in the above-mentioned one-step foaming, since the last foam of a request consistency is expanded at once when obtaining the foam of 10 times or more, deformation arises in the last foam obtained, and in case it takes out from metal mold, a crack arises in the foam, and there is a problem that the rate of commercial production becomes very low. On the other hand, since bridge formation of the foam is advancing considerably in two-step foaming at the time of post expansion, the diameter of air bubbles becomes small and there is a fault that foam with compressive stress high as the result is not obtained. Moreover, by heating the metal plate of metal mold from the outside, the manufacture approach of above-mentioned JP,2-42649,B makes medium primary foam heat indirectly, and manufactures the thick material foam which has a uniformly detailed (about 100 micrometers) closed cell. Furthermore, about the relation between primary and secondary expansion ratio and the diameter of air bubbles of the last foam, there is no reference in this.

**[0004]** This invention conquers the above-mentioned fault and aims at offering the last foam made to foam to 10 or more times, especially the method of manufacturing efficiently the thing [ that the diameter of air bubbles is as small as about 250–450 micrometers ] of the diameter of air bubbles which elapses and is not too large.

**[0005]**

**[Means for Solving the Problem]** Commercial production effectiveness is good only at modification of simple production conditions, and this invention person has a large diameter of air bubbles, he used to find out the approach of obtaining foam with high compressive stress, and used to complete this invention. Furthermore, if it says in detail, while securing the diameter of request air bubbles of the last foam by suppressing foaming in a primary high voltage condition below to some extent, and making it foam as much as possible in the ordinary pressure condition in secondary, it is going to prevent problems, such as deformation and a crack.

[0006] Namely, this invention is set to the approach of manufacturing the last foam made foaming to 10 or more times using the admixture which consists of polyolefine, a cross linking agent, and a foaming agent. It is filled up with the above-mentioned admixture in primary metal mold, and is this primary metal mold 50 kg/cm<sup>2</sup> By heating in the state of the above application of pressure Some of above-mentioned cross linking agents and above-mentioned foaming agents are made to disassemble, it decompresses after that, and it is made to expand primarily and the primary foam in which it is 1/7 or less, and primary expansion ratio has a less than 10-time coefficient of cubical expansion is manufactured to the total dilatation of the last foam in a coefficient of cubical expansion. Subsequently It is characterized by putting in this primary foam in secondary metal mold, heating by ordinary pressure, being 7 or more times, and making it expand secondarily with a less than 10-time coefficient of cubical expansion to this primary foam, and manufacturing the above-mentioned last foam.

[0007] In this invention with "polyolefine" For example, the high pressure process usually marketed, Polyethylene, ethylene propylene rubber which were manufactured by the medium-voltage method or the low voltage method, An ethylene-butene copolymer, an ethylene-vinylacetate copolymer, ethylene, and methyl, Ethyl, propyl, or a copolymer with each acrylic ester (the content of this ester; less than [ 45 mol % ]) of butyl, Or it is mixture with these things chlorinated to 60 % of the weight of chlorine content, respectively and also these two or more sorts of mixture, these and isotactic polypropylene, or atactic polypropylene etc.

[0008] The "cross linking agent" said to this invention is organic peroxide which is the radical generating agent which has the decomposition temperature more than the flow beginning temperature of polyolefine at least in the above-mentioned polyolefine, is decomposed by heating, generates an uncombined radical, and produces and cheats out of a crosslinking bond between the molecule. For example, it is dicumyl peroxide, 2, 5-dimethyl -2, 5-screw-tertiary butyl peroxyhexane, 1, and 3-screw-tertiary peroxy-isopropylbenzene etc. The "foaming agent" said to this invention has the decomposition temperature more than the flow beginning temperature of the above-mentioned polyolefine, and is an AZOJI carvone amide, dinitrosopentamethylenetetramine, etc.

[0009] moreover, metallic oxides, such as a compound which uses a urea as a principal component in this invention in order to control a foaming condition, a zinc oxide, and lead oxide, — low-grade or a higher fatty acid — or foaming assistants, such as low-grade or a metal salt of a higher fatty acid, etc. can be added. Furthermore, carbon black, a zinc white, titanium oxide, and other compounding agents in ordinary use can also be added for a physical-properties improvement.

[0010] Setting to this invention, the pressure in a primary expansion process is 50 kg/cm<sup>2</sup>. It is above. Under by this pressure, although based also on an expansion scale factor, when it considers as the conditions expanded to the neighborhood 10 times, the leak of foam arises, and it becomes the cause of deformation of a primary foaming article from metal mold, therefore decline in the rate of commercial production is invited. Moreover, it is carried out under ordinary pressure and post expansion is usually 20 kg/cm<sup>2</sup>. It will be processed under the following pressures.

[0011] Moreover, primary expansion ratio is 1/7 or less to the total dilatation of the last foam. When larger than this, the expansion force in post expansion becomes inadequate, and it becomes impossible to aim at improvement in cellular size. And it is most desirable to set preferably 120–150 degrees C whenever [ stoving temperature / of primary foaming ] as the comparatively low temperature of about 130–145 degrees C as a means to obtain such an expansion coefficient. The heating time can be selected to arbitration with the primary expansion ratio made into the object. Moreover, it is important for whenever [ in post expansion / stoving temperature ] to decompose thoroughly and to make a foaming agent foam, and it is desirable to set up in the range which does not have an adverse effect on polyolefine, it is about 160–190 degrees C, and the heating time is usually a 20 – 60-minute about room.

[0012]

[Function] According to examination of this invention person, as shown below, while obtaining the desired diameter (250–450 micrometers) of air bubbles by choosing proper primary expansion

ratio and a post expansion scale factor, it became clear that deformation of foam and a crack could be prevented. That is, when 1/7 or less, for example, the last expansion ratio, is 30 times the primary expansion ratio of this performed to the bottom of high voltage to the total dilatation, since foaming under high voltage serves as a subject when large, about 4.3 or more times and, the expansion force in post expansion becomes inadequate, and the diameter of average air bubbles becomes small too much with about 100 micrometers. If this becomes 10 or more times especially, deformation of primary and a post expansion object and a crack will also be invited further.

[0013] On the other hand, if it will consider as the post expansion scale factor of 10 times or more to primary foam in secondary foaming even if bridge formation is advancing, the diameter of air bubbles will become large rapidly. Since secondary foaming is performed in the state of ordinary pressure, if expansion ratio is enlarged to some extent above, this can obtain the expansion force which overcomes restraint by the bridge formation, and will be presumed to be what can attract amplification of the diameter of air bubbles rapid as the result. Therefore, this diameter of air bubbles is made not to become large too much, using a post expansion scale factor as less than 10 times. Furthermore, in the case of this expansion ratio of 10 times or more, deformation of a post expansion object and a crack will also be invited. Moreover, when this rate of post expansion considers as 7 or more times, the expansion force in post expansion is fully secured, and the about 250–450-micrometer diameter [ being small ] of foaming of the moderate magnitude which elapses and is not too large is secured.

[0014] As mentioned above, let the object be an achievement plug by setting up primary expansion ratio and a post expansion scale factor proper by suppressing foaming in a primary high voltage condition below to some extent, and making it foam as much as possible in the ordinary pressure condition in secondary. Moreover, a primary pressure is 2 50kg/cm. Since mold locking force is small when it is the following, it is easy to produce the leak of the foam in primary metal mold.

[0015]

[Effect of the Invention] As mentioned above, according to the manufacture approach of this invention, since there are not deformation and a crack, either, and the last foam which has the diameter [ being large ] of average air bubbles of the request which elapses and is not too small, and is excellent in compressive stress can be manufactured and there is also no leak of the foam from metal mold, the rate of commercial production is very good.

[0016]

[Example] Hereafter, an example explains this invention concretely. The constituent which becomes the polyethylene 100 weight section (henceforth the section) of a melt index 1.0 from the AZOJI carvone amide 10 section, the dicumyl peroxide 2 section, the zinc-oxide 0.5 section, and the white light oil 5 section was kneaded on the roll with a skin temperature of 100 degrees C, and admixture was obtained. And it was processed under various kinds of conditions which show this admixture in a table 1, and the 30 times as many last foam as this was manufactured. This result is also shown in a table 1. In addition, it separates from the figure which \* mark attached from this invention range among a table 1. Moreover, the unit of the figure of the column "be transformed and primary and a post expansion object should break" is a number among this table. [ the "foam leak in primary metal mold" column and ]

[0017] Furthermore, measurement of the diameter of average air bubbles measures the diameter of 100 air bubbles per each foam, and shows it by the average. Measurement of 25% compressive stress is JIS. It carried out by the approach of K6767.

[0018]

[A table 1]

表 1

	実施例1	実施例2	実施例3	比較例1	比較例2	比較例3	比較例4	比較例5
一次圧力( $\text{kg}/\text{cm}^2$ )	7.0	7.0	7.0	7.0	7.0	7.0	7.0	4.0*
一次加熱温度(℃)	13.0	13.0	13.0	13.0	14.0	14.0	13.0	13.0
一次加熱時間(分)	3.3	3.0	3.6	4.0	4.5	5.0	2.5	3.3
二次圧力( $\text{kg}/\text{cm}^2$ )	常圧	常圧	常圧	常圧	常圧	常圧	常圧	常圧
二次加熱温度(℃)	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0
二次加熱時間(分)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
一次発泡倍率	3.7	3.3	4.2	5	9	11*	2.7	3.7
全膨張率に対する比	1/8.1	1/9.1	1/7.1	1/6*	1/3.3*	1/2.7*	1/11	1/8.1
一次発泡倍率(対一次)	8.1	9	7.1	6*	3.3*	2.7*	11*	8.1
最終製品の全発泡倍率	30	30	30	30	30	30	30	30
加工回数	100	100	100	100	100	100	100	100
一次成型での発泡体割れ	0	0	0	0	0	0	0	19
一次発泡体の変形・割れ	0	0	0	0	0	7	0	14
二次発泡体の変形・割れ	0	0	0	0	0	2	6	11
平均気泡径 ( $\mu$ )	37.0	42.0	25.0	10.5	12.0	11.5	6.35	41.0
2.5%圧縮応力( $\text{kg}/\text{cm}^2$ )	0.61	0.61	0.48	0.32	0.31	0.30	0.69	0.61

[0019] According to this result, when primary expansion ratio is as large as five to 11 times (examples 1-3 of a comparison), the diameter of average air bubbles is as small as 105-115 micrometers, and compressive stress's is all small. In addition, when primary expansion ratio was as large as 11 times (example 3 of a comparison), deformation of foam and a crack were also produced. Moreover, with 635 micrometers, when a post expansion scale factor was as large as 11 times (example 4 of a comparison), while the diameter of average air bubbles was very large, it also produced deformation of a post expansion object and a crack. Furthermore, a primary pressure is 40kg/cm<sup>2</sup>. When low (example 5 of a comparison), while many leaks of the foam in primary metal mold arose, this was attracted and also produced much deformation of primary foam and a post expansion object and many cracks. On the other hand, in examples 1-3, since

the last foam which there is not, and has the diameter [ being small ] (250-420 micrometers) of average air bubbles of the request which elapses and is not too large, and is excellent in compressive stress can be manufactured and there is also no leak of the foam from metal mold, the rate of commercial production of all the above nonconformities is very good. In addition, in this invention, it is not restricted to what is shown in said concrete example, but can consider as the example variously changed within the limits of this invention according to the object and the application.

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**TECHNICAL FIELD**

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[Industrial Application] This invention relates to the approach the diameter of air bubbles manufactures efficiently the polyolefine foam made to foam to about 250–450 micrometers and 10 or more times which was greatly [ comparatively ] rich in compressive stress, if it says in more detail about the manufacture approach of polyolefine foam.

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**PRIOR ART**

[Description of the Prior Art] As the manufacture approach of the block foam of polyolefine How (one-step foaming is called hereafter.) to expand the consistency of at once a request of this admixture by filling up metal mold with the admixture of polyolefin resin, a cross linking agent, and a foaming agent, disassembling the cross linking agent and a foaming agent thoroughly in the state of application of pressure and heating generally, and decompressing after that And the method of filling up primary metal mold, heating admixture under application of pressure, expanding it primarily as indicated by JP,52-8348,B, JP,2-42649,B, etc., heating the foam by ordinary pressure after that, expanding the 2nd order, and obtaining the foam of a desired consistency (two-step foaming is called hereafter.) It is known.

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**EFFECT OF THE INVENTION**

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[Effect of the Invention] As mentioned above, according to the manufacture approach of this invention, since there are not deformation and a crack, either, and the last foam which has the diameter [ being large ] of average air bubbles of the request which elapses and is not too small, and is excellent in compressive stress can be manufactured and there is also no leak of the foam from metal mold, the rate of commercial production is very good.

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**TECHNICAL PROBLEM**

[Problem(s) to be Solved by the Invention] However, in the above-mentioned one-step foaming, since the last foam of a request consistency is expanded at once when obtaining the foam of 10 times or more, deformation arises in the last foam obtained, and in case it takes out from metal mold, a crack arises in the foam, and there is a problem that the rate of commercial production becomes very low. On the other hand, since bridge formation of the foam is advancing considerably in two-step foaming at the time of post expansion, the diameter of air bubbles becomes small and there is a fault that foam with compressive stress high as the result is not obtained. Moreover, by heating the metal plate of metal mold from the outside, the manufacture approach of above-mentioned JP,2-42649,B makes medium primary foam heat indirectly, and manufactures the thick material foam which has a uniformly detailed (about 100 micrometers) closed cell. Furthermore, about the relation between primary and secondary expansion ratio and the diameter of air bubbles of the last foam, there is no reference in this.

[0004] This invention conquers the above-mentioned fault and aims at offering the last foam made to foam to 10 or more times, especially the method of manufacturing efficiently the thing [ that the diameter of air bubbles is as small as about 250–450 micrometers ] of the diameter of air bubbles which elapses and is not too large.

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**MEANS**

[Means for Solving the Problem] Commercial production effectiveness is good only at modification of simple production conditions, and this invention person has a large diameter of air bubbles, he used to find out the approach of obtaining foam with high compressive stress, and used to complete this invention. Furthermore, if it says in detail, while securing the diameter of request air bubbles of the last foam by suppressing foaming in a primary high voltage condition below to some extent, and making it foam as much as possible in the ordinary pressure condition in secondary, it is going to prevent problems, such as deformation and a crack.

[0006] Namely, this invention is set to the approach of manufacturing the last foam made foaming to 10 or more times using the admixture which consists of polyolefine, a cross linking agent, and a foaming agent. It is filled up with the above-mentioned admixture in primary metal mold, and is this primary metal mold 50 kg/cm<sup>2</sup> By heating in the state of the above application of pressure Some of above-mentioned cross linking agents and above-mentioned foaming agents are made to disassemble, it decompresses after that, and it is made to expand primarily and the primary foam in which it is 1/7 or less, and primary expansion ratio has a less than 10-time coefficient of cubical expansion is manufactured to the total dilatation of the last foam in a coefficient of cubical expansion. Subsequently It is characterized by putting in this primary foam in secondary metal mold, heating by ordinary pressure, being 7 or more times, and making it expand secondarily with a less than 10-time coefficient of cubical expansion to this primary foam, and manufacturing the above-mentioned last foam.

[0007] In this invention with "polyolefine" For example, the high pressure process usually marketed, Polyethylene, ethylene propylene rubber which were manufactured by the medium-voltage method or the low voltage method, An ethylene-butene copolymer, an ethylene-vinylacetate copolymer, ethylene, and methyl, Ethyl, propyl, or a copolymer with each acrylic ester (the content of this ester; less than [ 45 mol % ]) of butyl, Or it is mixture with these things chlorinated to 60 % of the weight of chlorine content, respectively and also these two or more sorts of mixture, these and isotactic polypropylene, or atactic polypropylene etc.

[0008] The "cross linking agent" said to this invention is organic peroxide which is the radical generating agent which has the decomposition temperature more than the flow beginning temperature of polyolefine at least in the above-mentioned polyolefine, is decomposed by heating, generates an uncombined radical, and produces and cheats out of a crosslinking bond between the molecule. For example, it is dicumyl peroxide, 2, 5-dimethyl -2, 5-screw-tertiary butyl peroxyhexane, 1, and 3-screw-tertiary peroxy-isopropylbenzene etc. The "foaming agent" said to this invention has the decomposition temperature more than the flow beginning temperature of the above-mentioned polyolefine, and is an AZOJI carvone amide, dinitrosopentamethylenetetramine, etc.

[0009] moreover, metallic oxides, such as a compound which uses a urea as a principal component in this invention in order to control a foaming condition, a zinc oxide, and lead oxide, — low-grade or a higher fatty acid — or foaming assistants, such as low-grade or a metal salt of a higher fatty acid, etc. can be added. Furthermore, carbon black, a zinc white, titanium oxide, and other compounding agents in ordinary use can also be added for a physical-properties improvement.

[0010] Setting to this invention, the pressure in a primary expansion process is 50 kg/cm<sup>2</sup>. It is above. Under by this pressure, although based also on an expansion scale factor, when it considers as the conditions expanded to the neighborhood 10 times, the leak of foam arises, and it becomes the cause of deformation of a primary foaming article from metal mold, therefore decline in the rate of commercial production is invited. Moreover, it is carried out under ordinary pressure and post expansion is usually 20 kg/cm<sup>2</sup>. It will be processed under the following pressures.

[0011] Moreover, primary expansion ratio is 1/7 or less to the total dilatation of the last foam. When larger than this, the expansion force in post expansion becomes inadequate, and it becomes impossible to aim at improvement in cellular size. And it is most desirable to set preferably 120–150 degrees C whenever [ stoving temperature / of primary foaming ] as the comparatively low temperature of about 130–145 degrees C as a means to obtain such an expansion coefficient. The heating time can be selected to arbitration with the primary expansion ratio made into the object. Moreover, it is important for whenever [ in post expansion / stoving temperature ] to decompose thoroughly and to make a foaming agent foam, and it is desirable to set up in the range which does not have an adverse effect on polyolefine, it is about 160–190 degrees C, and the heating time is usually a 20 – 60-minute about room.

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**OPERATION**

[Function] According to examination of this invention person, as shown below, while obtaining the desired diameter (250–450 micrometers) of air bubbles by choosing proper primary expansion ratio and a post expansion scale factor, it became clear that deformation of foam and a crack could be prevented. That is, when 1/7 or less, for example, the last expansion ratio, is 30 times the primary expansion ratio of this performed to the bottom of high voltage to the total dilatation, since foaming under high voltage serves as a subject when large, about 4.3 or more times and, the expansion force in post expansion becomes inadequate, and the diameter of average air bubbles becomes small too much with about 100 micrometers. If this becomes 10 or more times especially, deformation of primary and a post expansion object and a crack will also be invited further.

[0013] On the other hand, if it will consider as the post expansion scale factor of 10 times or more to primary foam in secondary foaming even if bridge formation is advancing, the diameter of air bubbles will become large rapidly. Since secondary foaming is performed in the state of ordinary pressure, if expansion ratio is enlarged to some extent above, this can obtain the expansion force which overcomes restraint by the bridge formation, and will be presumed to be what can attract amplification of the diameter of air bubbles rapid as the result. Therefore, this diameter of air bubbles is made not to become large too much, using a post expansion scale factor as less than 10 times. Furthermore, in the case of this expansion ratio of 10 times or more, deformation of a post expansion object and a crack will also be invited. Moreover, when this rate of post expansion considers as 7 or more times, the expansion force in post expansion is fully secured, and the about 250–450-micrometer diameter [ being small ] of foaming of the moderate magnitude which elapses and is not too large is secured.

[0014] As mentioned above, let the object be an achievement plug by setting up primary expansion ratio and a post expansion scale factor proper by suppressing foaming in a primary high voltage condition below to some extent, and making it foam as much as possible in the ordinary pressure condition in secondary. Moreover, a primary pressure is 2 50kg/cm. Since mold locking force is small when it is the following, it is easy to produce the leak of the foam in primary metal mold.

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**EXAMPLE**

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[Example] Hereafter, an example explains this invention concretely. The constituent which becomes the polyethylene 100 weight section (henceforth the section) of a melt index 1.0 from the AZOJI carvone amide 10 section, the dicumyl peroxide 2 section, the zinc-oxide 0.5 section, and the white light oil 5 section was kneaded on the roll with a skin temperature of 100 degrees C, and admixture was obtained. And it was processed under various kinds of conditions which show this admixture in a table 1, and the 30 times as many last foam as this was manufactured. This result is also shown in a table 1. In addition, it separates from the figure which \* mark attached from this invention range among a table 1. Moreover, the unit of the figure of the column "be transformed and primary and a post expansion object should break" is a number among this table. [ the "foam leak in primary metal mold" column and ]

[0017] Furthermore, measurement of the diameter of average air bubbles measures the diameter of 100 air bubbles per each foam, and shows it by the average. Measurement of 25% compressive stress is JIS. It carried out by the approach of K6767.

[0018]

[A table 1]

表 1

	実施例1	実施例2	実施例3	比較例1	比較例2	比較例3	比較例4	比較例5
一次圧力( $\text{kg}/\text{cm}^2$ )	7.0	7.0	7.0	7.0	7.0	7.0	7.0	4.0*
一次加熱温度(℃)	130	130	130	130	140	140	130	130
一次加熱時間(分)	33	30	36	40	45	50	25	33
二次圧力( $\text{kg}/\text{cm}^2$ )	常圧	常圧	常圧	常圧	常圧	常圧	常圧	常圧
二次加熱温度(℃)	180	180	180	180	180	180	180	180
二次加熱時間(分)	40	40	40	40	40	40	40	40
一次発泡率	3.7	3.3	4.2	5	9	11*	2.7	3.7
全膨張率に対する比	1/8.1	1/9.1	1/7.1	1/6*	1/3.3*	1/2.7*	1/11	1/8.1
二次発泡率(対一次)	8.1	9	7.1	6*	3.3*	2.7*	11*	8.1
最終製品の全発泡率	30	30	30	30	30	30	30	30
加工ノ数	100	100	100	100	100	100	100	100
一次金型での発泡体割れ	0	0	0	0	0	0	0	19
一次発泡体の変形・割れ	0	0	0	0	0	7	0	14
二次発泡体の変形・割れ	0	0	0	0	0	2	6	11
平均気泡直径(μ)	370	420	250	105	120	115	635	410
2.5%圧縮応力( $\text{kg}/\text{cm}^2$ )	0.61	0.61	0.48	0.32	0.31	0.30	0.69	0.61

[0019] According to this result, when primary expansion ratio is as large as five to 11 times (examples 1–3 of a comparison), the diameter of average air bubbles is as small as 105–115 micrometers, and compressive stress's is all small. In addition, when primary expansion ratio was as large as 11 times (example 3 of a comparison), deformation of foam and a crack were also produced. Moreover, with 635 micrometers, when a post expansion scale factor was as large as 11 times (example 4 of a comparison), while the diameter of average air bubbles was very large, it also produced deformation of a post expansion object and a crack. Furthermore, a primary pressure is 40 $\text{kg}/\text{cm}^2$ . When low (example 5 of a comparison), while many leaks of the foam in primary metal mold arose, this was attracted and also produced much deformation of primary foam and a post expansion object and many cracks. On the other hand, in examples 1–3, since

the last foam which there is not, and has the diameter [ being small ] (250–420 micrometers) of average air bubbles of the request which elapses and is not too large, and is excellent in compressive stress can be manufactured and there is also no leak of the foam from metal mold, the rate of commercial production of all the above nonconformities is very good. In addition, in this invention, it is not restricted to what is shown in said concrete example, but can consider as the example variously changed within the limits of this invention according to the object and the application.

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[Translation done.]